Market Study for Stand Alone Wind Electric Generators

A Study

for M/s REPL Engineering Ltd.
Bombay

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EXECUTIVE SUMMARY

M/s. REPL Engineering Ltd. have identified Stand Alone Wind Electric Generators (SAWEG) as one of the areas of diversification REPL has already worked out collaboration arrangement with Survivor Energy Systems of Australia. TERI was requested to conduct the market-cum-feasibility study for REPL Engineering Ltd with two primary objectives. Firstly, to assess the market potential for SAWEG in India with the objective of making a 'go' or 'no go' decision for a marketing-cum-manufacturing venture by REPL Engineering Ltd Secondly, the study also intends to examine past or existing efforts in this direction and to work out an appropriate strategy Since REPL intended to market these systems in other developing countries, wind resources in developing countries are also reviewed

This study examines the market segments in different sectors i.e, domestic, agriculture, govt organizations and public sector organizations. Inferences are drawn from primary data collected through survey, personal discussions and interviews and the secondary data. Since the general conception is that industrial activity relates to large scale centralized production and hence is also associated with higher power consumptions and since there is no data available on small power applications in the industry sector, a survey was conducted by sending questionnaires to major industries and industrial groups throughout the country. Information about other sectors has been obtained either from secondary data or through personal discussions and interviews The exercise has been conducted at the national level and has not been conducted on a strictly regional basis *Due to the lack of data with respect to the demand for small power applications in various sectors, and the uncertainty about available data, rigorous attempts at working specific figures of market potential would not have served the purpose* However, past experience with SAWEG and the wind resources in remote regions of the country are considered in order to obtain indicative results

Review of existing power and energy situation in developing countries has shown that decentralized power supply systems are indeed relevant and there is a genuine need for such systems in the rural and remote areas A review of wind resources also shows that the there are vast regions with abundant resources and hence introduction of technologies like SAWEG which operate non depleteble and locally available sources would benefit the society.

However, the study, though encouraging in the sense that it indicates a high potential for the use of SAWEG like systems in India and other developing countries, does not paint a very bright picture about the prospects of actually marketing the machines in the existing market conditions which are far from mature. The study has shown that the technology has relevance and large technical potential for use in all the market segments considered. However, in the actual market, two important criterion associated with technology selection, i e , low costs and high reliability in supply, favor the competing options like diesel, grid electricity, kerosene and sometimes firewood As opposed to the large technical potential the actual commercial market for SAWEG in India and other developing countries is so low that it is very difficult for a fresh entrant like Survivor systems to capture an appreciable part of it On the other hand the costs of Survivor systems are higher by a factor of three

as compared to other equivalent systems in the market Therefore marketing of existing Survivor systems at current prices is impractical Even if Survivor costs are made competitive with the costs of existing SAWEG in the market, the actual marketing potential would still be too low to justify a venture in large scale manufacturing of the systems in India. While it is expected that large scale manufacture will bring down the costs to some extent, the technology would still be far from competitive.

The only way this technology can become commercially attractive to the user is through certain policy interventions to be taken by the government e.g. a decision to meet rural energy needs by decentralized technologies. The government's policy towards the development and promotion of SAWEG and other decentralized electricity generation technologies is yet to crystalize Unless there is comprehensive package of incentives to the users (as in the case of grid connected wind turbines), the market will remain immature in the country.

In view of the fact that REPL has already worked out an arrangement for collaboration and has committed itself to Renewable Energy Technologies, we suggest following strategy towards business development with SAWEG.

- To postpone the planned manufacturing facility for SAWEG till the market is mature, and at least till favorable government policies for decentralized electricity generation are in place

- To set up an assembly plant to assemble the SAWEG from off the shelf and imported components However, this assembly plant should not be in the nature of mass series production, but on a much smaller scale with the maximum capacity to assemble 5 to 6 turbines in a week

- In order to reduce the market price of Survivor systems, vendor development and indigenization of the components should be taken up immediately

- To market the systems, REPL has to reduce the price in order to introduce the systems at a price which is competetive with the price of other similar systems in India.

- Schemes should be worked out with the help of financial institutions to lease out systems to the users or to offer the systems to users on easy installments In this connection REPL should approach IREDA which is providing soft loans for activities on renewable enrgy technology development

- REPL should build and operate systems for remote communities for a certain reliability (i.e to meet a certain minimum firm power of a high priority load) at a certain agreed rate of electricity to the users

- REPL should consider certain design changes like design of systems which can be easily dismantled and transporeted so as to make the Survivor systems suitable for a range of applications i e army units, off shore applications

REPL should also undertake R&D to develop hybrid systems like wind diesel and wind-PV in order to improve the overall system reliability MNES or PACER secretariat of ICICI can be approached for partial funding for such projects

- Selling of Survivor systems can also be linked with the marketing of high efficiency devices like CFL as the scope and market for supply of such devices increases with the increase in installations of SAWEG or similar decentralized systems. In this case attempts can be made to share resources for marketing and advertizing of Survivor systems, CFL, inverters etc

- REPL should set up some demonstration units.

- Lobbying for a clear set of incentives from government should simultaneously be carried out by means of representations, seminars, guest lectures and articles in Newspapers

- A sustained advertizing campaign should be carried out to increase the awareness of all concerned towards these systems. Emphasis should be laid on environment friendly nature of technology and the teetering system of the turbine.

- REPL should also lobby with international aid agencies for soft loans or grant under the framework of environment and sustainability

- Initially this activity does not require a major manpower commitment. In fact one qualified marketing cum engineer professional for marketing and vendor development and two to three trained technicians for assembly and service would suffice The manpower can be increased gradually with the increase and expansion of activities

- The target segment for initial marketing should be government and public sector organizations, hotels, plantations, diaries, cooperatives, state nodal agencies The target geographical regions should be entire coastal stretch of India with emphasis on Gujarat, Tamilnadu and Kerala. Attempts can also be made to sell the systems for off shore applications

1.0 INTRODUCTION

1.1 GENERAL

Increasing population, aspirations for improved living standards and general economic and industrial growth in most of the developing countries result in an increasing energy demand However, due to the environmental constraints and the risks associated with high dependence on fossil fuel based energy generation, further capacity addition with conventional centralized methods would be constrained Electricity generation by conventional means is an established source of pollution The growing realization of the magnitude and severity of the world's pollution problems has made us aware of the dangers of global warming and the risks to natural habitat of burning fuels and using nuclear power Security of energy supply particularly the venerability of developing world was brought sharply into focus world wide by the Gulf war In the context of developing countries greater use of renewable sources of energy, efficient use of energy and increasing the forest cover have reasons more compelling than the threat of climate change induced by green house gasses (GHGs). Sustainable energy systems demand the ultimate reliance on renewable forms of energy[1]. Strategies for supplying the developing world with electricity must take these issues into account.

As a result of increased attention towards alternative forms of energy and methods of conversion and their growing economic viability, the significance of renewable energy devices operating in dispersed and decentralized mode as serious components of modern energy supply has been growing Different technologies based on renewable sources of energy have been developed and/or deployed in attempting to build sustainable energy systems which also reduce environmental concerns such as that of climate change. Much more, however, remains to be done. The part which renewable energy can play in meeting the increasing demand for clean electricity is not fully appreciated and the potential of wind energy has largely been ignored Wind energy is one of the clean and renewable energy sources which holds the promise of meeting a significant portion of energy demand in both, direct grid connected mode and the remote stand alone "niche" applications

1.2 INTERNATIONAL DEVELOPMENTS

The first large scale utilization of wind energy took place in form of grid connected windfarms in California in the early eighties The windfarms in California established the technical and economic viability of grid connected WEG At present large windfarm projects are being planned or are under implementation in USA, western and north western Europe and India. Some windfarms have also come up in China and Egypt It can be seen in Exhibit 1 that the rate of installation of windfarms is on the increase both in Europe and India While in India, to some extent, it has to do with power shortages, European electricity sector has discovered this to be the only way of complying with their government's clean air legislation.

1.3 RESOURCE REGIONS IN DEVELOPING WORLD

In 1988 the worlds' requirement for electricity was equivalent to two thousand, 500 MW power stations operating continuously. Assessment of wind energy resource in the world is difficult, but calculations have been performed. One estimation places the extractable energy in the surface winds, keeping in view all possible constraints and limitations, at the order of 10^3 GW worldwide[2]. Whatever the precise figure, there are various considerations which limit the proportion which could be used. Taking technical and human constraints together but ignoring the economic constraints, it is suggested that an absolute maximum of 10% of the raw wind potential could be put to use. This is equivalent to all the world's electricity needs. A figure of 1% - still 10% of the requirement - may be more realistic. The precise figures are not important. The wind energy potential is vast and by exploiting only a minute proportion of it, a very significant proportion of the requirement for electricity can be met. The world-wide wind energy resource distribution shows that typically, wind speeds are high in higher latitudes. Following these average distributions, one would expect generally high wind speeds in southern parts of South America, southern Africa and northern China. In the tropical and sub-tropical regions of the developing world comprising of the Indian subcontinent, middle east, Brazil and northern Africa, one would expect generally lower wind speeds. However, wind is modified locally by differences in the heat capacities of water and land, topographic features and vegetation. These smaller scale features can cause considerable variations in wind energy over relatively short distances, particularly over coastal or mountainous areas. The examples are the Aralvoimozhy gap in South Tamil Nadu, India, where average annual wind speeds of about 8 m/s are experienced due to the "tunnel effect" of the gap and where already about 12 MW of windfarm capacity is operational. Similarly Fujian province in south eastern coastal area of China which is bounded by Dai Yun mountain range and the central mountain range of Taiwan experiences average annual wind speeds of 6.5 m/s to 8.5 m/s[3]. Although the area under such regions is small on a global scale, it is significant in terms of potential for wind powered generation. A broad country wise description on wind resources is given below.

China: The country is known to experience high wind speeds among stretches of its eastern and south eastern coastlines extending from Jilin province, east Linning province, Zhejiang province, parts of Shandong province, Fujian province and islands off Guangdong. Several sites with average annual wind speeds higher than 6 m/s have been identified along this coastal stretch. Wind speeds as high as 11.7 m/s are experienced at Tian Pool in Jilin district. High wind speeds are also experienced in Inner Mongolia Autonomous region, Northern Gansu Province and Tibet[4].

Taiwan: Taiwan has some regions with wind speeds > 6 m/s. The wind energy potential in the country is estimated to be of the order of 1000 MW most of which exist mainly in the west coast and Peng-hu islands.

India: India has been quick to realize the potential and significance of wind power. Till recently, the country was regarded as a region with low or mediocre wind speeds. However, wind mapping and the wind monitoring program initiated by the Ministry of Non-conventional Sources has resulted in identification of several sites with wind speeds higher than 6 m/s Some of the sites, due to the complex terrain effects, experience wind speeds in the range of 8 5-9 5 m/s. The potential regions are the coastal areas, inland gaps and ridges in Tamil Nadu, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, parts of Orissa, parts of Kerala and some regions in Himalayas like the Ladakh region

Egypt: Wind energy resource assessment carried out in 1984 has revealed that regions near the Red Sea and on the Mediterranean coast experience average wind speeds from 6-10 m/s.

Namibia: The oldest desert in the world, the Namib desert covers 15% of the total land area and extends along the entire coastline The Kalahari desert forms Namibia's south eastern border with Botswana. It is felt that existence of deserts near the coast will cause high temperature and pressure gradients between the sea and desert and the desert and the adjoining land masses These gradients will cause high surface winds along the western coast and to some extent in the inland areas on the fringe of the desert and the relatively green land mass It can, therefore, be concluded, even in absence of data, that Namibia is reasonably windy country with the possibility of some extremely windy pockets experiencing wind speeds of the order of 7-8 m/s

Iraq: Sixty percent of this country is desert and 16% of the country has relatively high wind speeds of the order of 5-6 m/s

Sri Lanka: There are sites south of Sri Lanka with mean annual wind speeds higher than 6 5 m/s There is a possibility of integrating windfarms with the hydro reservoirs of the island

Chile: Meteorological data collected on the west coast of South America at 10 m heights shows wind speeds of the order of 9 m/s at some sites

Argentina: Sites with annual wind speeds as high as 9-11 m/s have been found in this country, South east coast and locations in Andes are known to experience wind speeds higher than 6 m/s

Other Countries: The other countries with potential regions are Lebanon (Mediterranean Coast and Mountains (>5 6 m/s), Algeria (Atlas Mountains, Interior Desert (>5 6 m/s), Madagascar (Coastal and Mountains, >5 6 m/s).

1.4 POWER/ENERGY SECTOR IN DEVELOPING COUNTRIES

All developing countries are characterized by power and energy deficits The energy sector in India has been considered a priority area in development planning With the growth in the economy and increased mechanization of agriculture and allied activities, the commercial energy consumption including electricity has grown rapidly and the demand for power continues to grow at a rapid rate outstripping the availability for the same The rate of growth of electricity consumption which averaged 12.19% per annum compounded during the decade 1960-61 to 1970-71, declined sharply to 6.54% during the decade 1970-71 to 1980-81 mainly due to the limited availability of power It has since improved and the growth rate in energy consumption has averaged at 9.16% in the nine year period ending 1989-90 even though the shortages of power still persist Power generating capacity which is largely owned and operated by utilities (SEBs), has grown at the rate of over 9.7% r annum since 1950 The power supply situation in India is characterized by peak and energy shortages which are likely to continue over the next several years Despite an increased investment in and outlay for power, a 7.7% deficit in demand is projected for 1994-95[5]. Due to the limited resources available for new investments, the central government, state governments and the utilities are facing new challenges in implementing capacity expansion plans. On the other hand the productivity in the industrial & agricultural sectors is adversely affected by these shortages. The enormous strain under which the expansion has been taking place recently, has not permitted energy sector organizations to attain levels of efficiency that might bring about optimal use of resources at their command The main issues in the energy sector are an absence of an integrated long-term energy policy for the country, lack of rational pricing of energy supply, increasing foreign exchange outflows, low levels of useful energy availability, increasing energy demand, *lack of an integrated approach towards decentralized energy systems* and low efficiencies of utilization

Hence the major considerations in examining the alternative options for energy development are to develop environmentally beneficial alternatives, which will also reduce oil consumption, and overall energy shortages Till recently the use of biomass, solar, wind, wave and other renewable energy sources in India were all at the experimental stage However, in recent years favorable incentives and government policies has led to near commercialization of grid connected wind turbines and biogas plants Till a few years ago, there was no coordinated national policy on the renewable energy technologies In 1979, the Working Group on Energy Policy expressed the "growing realization" that rural energy needs could be met from "decentralized supply systems based on alternative energy technologies" The group listed five such "promising" technologies

- Solar energy for supplying low-temperature heat for water heating and post harvest operations

- Biogas plants to supply heat, provide mechanical energy by its use in internal combustion engines and meet lighting needs either with gas mantles or through electricity.

- Producer gas plants based on charcoal to run mobile equipment.
- Microhydel stations to provide electricity

It recommended, that all these technologies could be used either immediately or in the very near future. However, the group also pointed out that a large number of rural people did not use the electricity or kerosene because these fuels were either too costly or cheaper alternative, such as firewood, were more easily available. "*Alternative energy technologies should, therefore, be very cheap or their use must be made much more convenient than conventional fuels like firewood*", the group said. This statement, though made in the context of cooking energy, to some extent also holds true for other end uses in the rural sector.

China's total installed generating capacity is over 100 GW with electricity generation of 500 TWh/yr. Urban or developed areas with 20% of the population account for 80% of electricity consumption. Consequently, one third of the population lives in non-grid connected areas. Electricity shortages exist.

Egypt has proven resources of oil, gas, hydropower and to some extent coal. In 1987/88 proven reserves of oil and natural gas were 480 million metric tones and 12 trillion cubic feet respectively. At present the country exports energy. But demand forecasts indicate that beyond the year 2000, the country may have to import energy. In the last ten years (1982-1991) domestic consumption of energy grew @ 5.5% annually while energy exports of crude oil and petroleum products grew at a lower annual rate of about 2%.

In general, all developing countries are either facing energy and power deficit or like in the case of Egypt may have to face crises in the near future. The expert opinion is that particularly in India, the rural energy situation is assuming crisis proportions in several places[6]. Moreover, number of villages claimed to be electrified by Rural Electrification Corporation (REC) does not imply that all the households in these villages have been electrified. The electrification as per present definition implies that even if only one or few households in the village have the facility, the village is considered as electrified. Therefore very few houses even in electrified households have electricity connections and even this connection supplies poor quality and unreliable power supply[7].

1.5 AUTONOMOUS POWER STATIONS

Two straight forward conclusions can be drawn from the situation described above, first, that the conventional approach of meeting electricity requirements by large centralized power stations transmitting power over large distances by transmission lines (grid) is impractical in the context of developing countries and second, that there is not only a need but also a real market (yet to be tapped) for supplying, setting up and operating reliable autonomous power stations working on locally available resources for remote communities. Such autonomous systems could realize the unfulfilled objectives of rural electrification in both remote non grid connected areas and in grid connected areas served by an unreliable grid. Therefore, the concept of renewable energy based autonomous power systems have the multi-attributes of being environmentally sound, meeting the end use requirements and being an option for demand side management. While the relevance of these systems to the rural sector of developing countries in general and to that of India in particular is well established, it remains to be seen how a number of technologies falling in this category can be integrated with the conventional energy supply systems in India

Meeting rural energy needs by decentralized renewable energy systems has been on the agenda for quite a few years now Therefore in the context of developing countries sustenance of developmental activities would in the long run depend upon locally available alternative forms of energy

Exhibit 1:

Despite the fact that the major installations of wind energy systems all over the world are in the form of grid connected windfarms, there is also an exclusive market for "stand alone" or autonomous systems all over the world It is widely acknowledged that this market is potentially vast Many developing countries will probably venture into wind energy by introducing small systems for pumping water and battery charging There are also uses for stand alone systems in the developed world where the power is required at a costly distance from the grid.

In rural districts of the developing world, the level of energy consumption per capita is very low The basic energy needs are for pumping water, electricity for hospitals, lighting, cooling, and telecommunications In vast rural regions these needs can not be met by centralized energy production systems because the cost of transmitting energy to sparsely populated locations is prohibitive. There is therefore a growing demand for decentralized power systems, such as diesel pumps and generators, solar photovoltaic and wind energy systems There is also a very large market for applications like energization of warning signals, telecommunication units, light houses, army applications, monument lighting, offshore applications etc Such small applications are usually so remote and dispersed that it is prohibitively costly to charge these or to supply fuel at the end use Autonomous power systems based on wind or photovoltaic appear to be the appropriate options for these applications It is felt that there may also be a significant market with industries, particularly those involved in activities involving large areas like plantations, saltworks etc Wind energy is a serious competitor and an important option for electricity supply to remote applications, even in regions with moderate wind speeds There has been considerable progress in the development of modern wind pumps for irrigation, cattle watering and the supply of domestic water. An indication of the size of market is the number of classical wind pumps now in use, estimated at well over a million In regions with moderate to good wind speeds, small wind generators are competitive If a large part of the machine can be produced locally, the technology becomes still more attractive On a somewhat larger scale,

- Electrification of rural communities.
- Electrical requirements of dispersed and remote communities in hill districts
- Power for remote residences and farm houses.
- Electricity for space heating and cooking.
- Electricity for rural based small scale or cottage industry.
- Water pumping for drinking and irrigation purposes.
- Water desalination.
- Street Lighting and lighting of community places
- Communication systems for remote communities.
- Very low power TV transmitters
- Medical refrigerator systems.
- Crop sprayer
- Lighting and electricity requirements at parks and forest reserves.

Exhibit 2: List of applications of Small Wind Battery Chargers

prototype wind diesel systems are operating in a number of countries such as china and Philippines These systems are already , or certainly will become, competitive in locations and for applications where the kilowatt hour prices are tied to the costs and availability of oil and its transport over long distances

2.0 STUDY DESCRIPTION

2.1 OBJECTIVES

The main objective of this exercise is to assess the market potential for stand alone wind electric generators in India with the objective of making a 'go' or 'no go' decision for a marketing-cum-manufacturing venture by REPL Engineering Ltd. The study also intends to examine past or existing efforts in this direction and to work out an appropriate marketing strategy

2.2 APPROACH

. tempted to examine the market segments in different sectors i.e, domestic, agriculture, ganizations and public sector organizations These sectors are further evaluated under different sub categories Finally, market potential is assessed for different end uses i e crop drying, battery charging, domestic lighting etc Inferences are drawn from primary data collected through survey, personal discussions and interviews and the secondary data. Since the general conception is that industrial activity relates to large scale centralized production and hence is also associated with higher power consumptions and since there is no data available on small power applications in the industry sector, a survey was conducted by sending questionnaires to major industries and industrial groups throughout the country Information about other sectors has been obtained either from secondary data or through personal discussions and interviews

The exercise has been conducted at the national level and has not been conducted on a strictly regional basis As mentioned in the introductory chapter itself, the technologies like stand alone wind electric systems are relevant to India and, therefore, we assume that there is in fact a large potential for their use Hence our efforts have been concentrated at identifying market segments, identifying measures required from the govt to promote this technology and at working out the marketing strategies *Due to the lack of data on various sectors and uncertainty about available data, rigorous attempts at working specific figures of market potential would not have served the purpose* However, case studies and windy and remote regions in the country are considered in order to obtain indicative results assessing the market potential

3.0 CURRENT STATUS

3.1 WIND POTENTIAL IN INDIA

SAWEGs can successfully operate even in regions with relatively lower wind speeds (~4m/s mean annual). Before attempting to assess the wind energy potential, it is important to have a clear understanding of the term 'potential'. All exercises in the past on potential assessment were made in the context of windfarms. MNES placed the potential for windfarms at 20,000 MW while TERI in a study assessed the realizable economically viable potential for windfarms at 45000 MW (Hossain 1991) Above exercises take into account prevalent wind speeds, land availability and constraints due to grid Assessment of potential for stand alone applications would be different and more difficult to assess It is also felt that this potential should not be assessed in watts, a more meaningful unit will be numbers of households, light houses, beacon units etc that can be electrified As mentioned above attempts to arrive at numbers and figures would be defeating, therefore, we limit ourselves at identifying potential regions and potential applications It has been mentioned above that the potential regions in India are the coastal areas, inland gaps and ridges in Tamil Nadu, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, parts of Orissa, parts of Kerala and some regions in North East and Himalayas like the Ladakh region. It can be seen in Exhibit 4 that from the sites for which wind speed data is available, there are a large number of sites all over the country where mean annual wind speeds are higher than 4 m/s.

3.2 CURRENT ACTIVITIES

Although there has been much interest in wind electric generators from both private sector and govt organizations, the technology being vigorously pursued is grid connected wind turbines which are suitable only for regions with stable grid. One of the potential technologies for decentralized electricity generation, the stand alone wind electric generators and small wind battery chargers from few hundred watts to 10 kW, have not been considered or pursued in the wind energy programs of the country This is mainly due to lack of entrepreneurship and suitable project designs both of which are important for trouble free operation of the systems In past MNES acquired several of these systems to be installed in different regions of the country. However, the locations of these systems were so remote and the capacity so small that trouble free operation and maintenance became prohibitively costly and difficult. Till date MNES programs have led to installation of 107 SAWEG of 50 Watt to 4 kW unit capacities in different parts of the country In addition 5 no of 10 kW SAWEG have been installed in Ladakh, West Bengal and Lakshadweep islands

These projects are often characterized by delays, disputes over sites, vandalism, disputes between MNES, user and the supplier of machines, accidents and the lack of maintenance Though, one may conclude that these demonstrational projects are not a success, some very useful lessons can be learnt on designing successful remote area power system projects Most of these projects have failed because of inherent flaws in project design, failure in project management or due to lack of maintenance & poor sites

3.3 *GOVT. INCENTIVES FOR WIND POWER DEVELOPMENT*

The government strategy towards the development of windfarms is very clear There is a comprehensive package of incentives and a program for promotional activities However, ugh some of the incentives for windfarms are applicable to SAWEGs (Stand Alone Electric Generators) also, the technology does not seem to be receiving the same thrust as the windfarms. There are fewer suppliers of SAWEG in India who have so far been depending entirely on purchase orders from MNES These suppliers to the best of our knowledge have not even made any serious attempts to sell the machines to other govt and public sector organizations like DoT, Railways, Doordarshan, Army, ONGC etc There has been absolutely no effort to sell and setup machines to cooperatives, village panchayats and remote settlements It is felt that with some initiative from private sector, the govt policy would also crystalize on this technology. The existing incentives include import duty relaxation on the import of some components and availability of soft loans (@ 14 5-15 5%) for ventures in SAWEG from Indian Renewable Energy Development Agency (IREDA)

Station	(4-5 m/s)	Station	(5-6 m/s)	Station	(>6 m/s)
Bangalore	4.20	Indore	5.90	Tuticorin	6.30
Bhopal	4.09	Veraval	5.55	Kandla	6.11
Meenakshipuram	4.49	Coimbatore	5.30	Mandvi	6.51
Jamnagar	4.51	Devgarh	5.48	Okha	6.71
Madras	4.37	Andipatti	5.29	Muppandal	7.06
Tiruchirapalli	4.35	Kayattar	5.73	Dhank	7.50
Alibag	4.13	Dwarka	5.55		
Aminidivi	4.36	Kanyakumari	5.81		
Bhuj	4.25	Keshode	5.47		
Bidar	4.20	Porbandar	5.33		
Dahanu	4.67	Puri	5.15		
Dohad	4.47	Rajkot	5.57		
Goa Marmagao	4.48	Sagar Island	5.72		
Gopalpur	4.87	Sandheads	5.01		
Harnai	4.97	Poolavadi	5.81		
Jaisalmer	4.83	Puliyankulam	5.40		
Jalgaon	4.25	Tondi	5.52		
Kodaikanal	4.04	Sembagaramanpudur	5.95		
Chandipur	4.89	Sultanpet	5.03		
Mahabalashwer	4.33	Harshad	5.97		
Chatrapur	4.31	Paradeep	5.19		
Nagapattinum	4.32	Vijaydurg	5.54		
Kaipadar	4.22	Bhavnagar	5.35		
Naliya	4.15				
Pamban	4.80				
Tambaram	4.97				

Exhibit 3: List of sites with mean annual wind speeds greater than 4m/s at 25 m height.

4.0 STATE OF THE ART OF TECHNOLOGY

4.1 TYPICAL SYSTEM DESCRIPTION

The SAWEGs installed in India are in the range of 100-25000 Watts Nearly all these turbines are meant for charging batteries and most of them are horizontal axis wind turbines (HAWT) except a 5 kW vertical axis wind turbine being developed by BHEL under sponsorship of MNES. In India all the machines are HAWTs

Most of the SAWEGs use permanent magnet alternator with a rectifier which feeds d c output to the battery bank. An inverter is often incorporated with the system, however for certain applications like just lighting an inverter is not necessary The electricity generated by the system varies with wind speeds in accordance with the power curve specified by the suppliers A typical power curve is shown in figure 1 The power curve is characterized by three characteristic wind speeds,i.e, **Cut-in** wind speed at which the alternator starts generating electricity, **Cut-out** wind speed at which the machine is stopped, however, in case of certain machines there is adequate regulatory mechanism to allow functioning even at high wind speeds and **Rated** wind speed at which the rated power of the SAWEG is delivered The power output in the range rated to cut-out wind speeds remains nearly constant

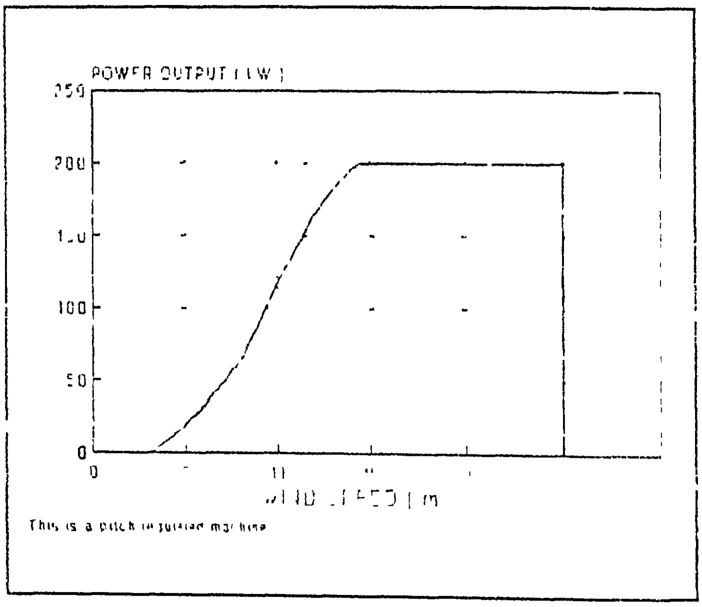

Figure 1 A typical power curve

4.2 SYSTEM CLASSIFICATIONS

It is often desirable to operate stand alone systems with a back up source which significantly enhances the overall power supply reliability of the system Such systems are called hybrid systems The Hybrid wind electric systems can be either operated with a fuel engine back up or photovoltaics or hydro which can either be of a capacity higher than that of the wind plant, of the same order or smaller. The components/sub-systems of the turbine in hybrid systems are similar to those of SAWEG or grid connected wind turbines However, there are major differences in controls, wind-fuel interphase storage and power regulation. Storage is needed to limit the start and stop cycles of the fuel engine and to ensure the reliability of supply The autonomous systems in the strict sense are seldom used as some storage back up is always there. Design of an hybrid system requires care sizing of each of the elements i.e. battery bank, wind turbine, diesel/pv/hydro (if any). Sometimes it may be economical to operate the hybrid system on more efficient end use appliances like CFL instead of investing in higher rating equipment on the generation side. Depending upon the control strategy and the capacity of plants and storage the hybrid systems can be further classified into number of different types of systems. Generally, the autonomous systems can be categorized in three broad groups:

1) The electrical energy is only supplied by a wind turbine

2) The electrical energy can be supplied by a wind turbine and/or a fuel (diesel) generator with an installed power of the same order as the installed power of the wind turbine

3) The electrical energy can be supplied by a wind turbine and/or a fuel (diesel) generator with a much larger installed power than the wind turbine

A brief description of these systems is given in the following sections.

4.3 AUTONOMOUS SYSTEM WITHOUT AN AUXILIARY FUEL ENGINE

In these systems a synchronous generator is driven by a wind turbine and there are two possible techniques to control the frequency of the autonomous grid

Blade pitch control In this technique the angular speed (and frequency) is kept constant above certain wind speeds by blade pitch control, activated by centrifugal weights

Blade pitch control combined with the load control The pitch of rotor blades is controlled by a centrifugal controller via a hydraulic system, in such a way that the speed of the synchronous generator is kept constant, as long as the demanded power is less then the minimal power of the wind turbine When the demanded power exceeds the minimal power of the wind turbine The load is switched off by priorities until the maximum power of the wind turbine is more than the demand

4.4 AUTONOMOUS SYSTEMS WITH A FUEL ENGINE HAVING A RATING SIMILAR TO THAT OF WIND TURBINE

These systems are designed to offer a constant supply of energy. independent of the wind speed. Such systems during operation may encounter three different situations

- The demand is less than the power available from wind turbine and all the demand power is supplied by the wind turbine
- The demanded power is more than the power available from wind turbine and the parallel operation of wind turbine and the fuel engine takes place.
- No wind power is available and all the power is supplied by a fuel engine.

The frequency control is again a major problem and the alternative techniques are

- By means of controlling the field current of synchronous generator
- By controlling the rotor slip power of the induction generator.
- By using dump loads.
- Mechanically varying the RPM of rotor to keep the frequency constant
- By using controllable speed varietur which gives constant RPM on the output shaft.

4.5 AC SYSTEMS WITH FUEL COMPONENT OF MUCH HIGHER RATING THAN THAT OF THE WIND TURBINE

These systems are not autonomous systems but supplement the diesel grid which is comparable with a strong utility grid The demanded power is always greater than the power supplied by the wind turbine so there is no need for an extra load to control the power balance. The frequency in all cases is controlled by the diesel's governor In nearly all known systems the wind turbine drives an asynchronous generator

4.6 BATTERY STORAGE SYSTEMS

There are a number of small DC systems up to 5 kW combined with an inverter to get AC output These systems are composed of the following major sub-elements

- a wind turbine with a DC generator or an AC generator (permanent magnet synchronous) with a rectifier
- a storage battery
- a voltage source inverter

Small capacity battery storage systems are usually used to supply DC loads and inverters are not used.

4.7 FUTURE CONCEPTS

The technology related to wind turbine in a SAWEG is well established and developed However, R&D on some aspects continues at different levels and changes are expected in commercial SAWEG of future. These systems are described in annexure II

4.8 PRODUCT DESCRIPTION

The SAWEGs selected by REPL engineering for marketing and indigenization in India are the machines of Survivor Energy Systems, Australia. Survivor makes machines of different ratings with rotor diameters varying from 5 8 m to 2 7 m. A special design feature of these machines is the power regulation with teetering hub This rotation of hub/rotor assembly in the vertical plain results not only in power regulation but a reduction dynamic levels of structural loads. Similar machines are also being made in U S. and attempts have been made to apply the same concept of power regulation to grid connected wind turbines The balance of the system in survivor machines is similar to other SAWEGs as discussed above

4.9 PRODUCT COST

A 2 7 m rotor dia survivor system has been priced at a cost higher than Rs 4 0 lacs and with the balance of system costs this price would exceed Rs 5.0 lacs This price does not compare well the prices of other SAWEG systems being currently marketed in India e.g The SOMA, a make from New Zealand is selling a 2 6 m dia and 1000 watt SAWEG at a price of Rs 1 15 lacs in India Even these relatively cheaper machines have not been able to capture any sizeable market portion to justify setting up of manufacturing facilities

5.0 APPLICATIONS POTENTIAL

5.1 RURAL SECTOR

Agriculture is the primary occupation in the rural sector. Direct commercial energy inputs in agriculture are largely for two activities; mechanized land preparation and mechanized lift irrigation. although commercial energy is also required for harvesting, threshing, drying and winnowing. It can be seen in Exhibit 5 that Irrigation requirement for irrigating non irrigated area under crops is 405384 Million kWh A stand alone system Survivor Model S-3000 is expected to generate 4 15 kWh/day in average annual wind speed of 4.64 m/s This corresponds to 1514 75 kWh/yr. If this system is considered for pumping water for irrigation and if we assume 90% pumping efficiency and 90% for other losses, the useful energy generation for pumping from a single survivor system turns out to be 1227 kWh/yr If ten thousandth fraction of the irrigation potential worked out above is met by Survivor Model S-3000, we would need 33,000 systems If this requirement is met over a period of 20 years one would need manufacturing capacity of 1600 units per day This is a conservative estimate just to meet ten thousandth fraction of irrigation requirements of the area under crops not irrigated we have not even considered the possible penetration of the technology to irrigated areas The exercise also demonstrates that the numbers we would arrive at in this manner for market potential are indeed very large and probably there is little purpose in that as the real size of manufacturing facility to be set up by REPL would be smaller subject to constraints of finance, trained manpower, linkages in the rural sector and awareness about the technology In addition to irrigation the other end uses which can be considered are threshing, drying & grain grinding An important characteristic of agricultural end uses is that though the requirements are seasonal, they do not require very high reliability from the power generating system (i e the energy can be used as and when available during the day), therefore, even cheaper system designs with low storage capacities would be optimally utilized

In the domestic rural sector the main end uses are drinking water, cooking and lighting Though there is a distinct possibility of using excess electrical energy for cooking purposes we do not consider this end use in our analysis because traditionally fuel wood or kerosene stoves meet these requirements However, drinking water requirements and lighting can be met by this end use It is obvious that an attempt to work out a figure for market potential in these applications would again yield a very large number, *It is sufficient to be aware of the application and to know how a SAWEG can meet the requirement and what is the strategy* In the case of lighting we examine two alternatives, first, in which inefficient incandescent bulbs are used for lighting by the villagers and second, efficient but costly CFL tubes are used for this purpose with a SAWEG If three 60 watt lamps are considered for providing lighting for six hours in each household, single Survivor S-3000 can meet the electricity requirements of 4 houses in a region with mean annual wind speeds of the order of 4 64 m/s (say district Rajkot), on the other hand if four 9 watt CFL tubes instead of 3 incandescent bulbs are used in each house hold to provide same lumens or more, the same survivor can meet the requirement of 19 house holds

We consider the possibility where REPL instead of marketing SAWEG decides to market electricity generated from the SAWEG, in such a case it turns out to be more economical to install a SAWEG with the CFL option instead of installing 4 SAWEGs The example is being given to make the point that as a marketing strategy REPL would have to promote efficient domestic appliances in order to effectively market survivor in rural domestic sector This may also lead to sharing of resources with the organizations involved in manufacturing CFL and like products. Of the decentralized renewable energy systems being promoted in the rural domestic sector 10 W photovoltaic lantern with single CFL has found wide acceptance A PV lantern of this type costs about Rs. 5500 and there is a government subsidy of about Rs. 4000 on each unit. The cost of meeting the lumen requirement in the above example by PV lantern would be Rs 4,18,000 inclusive of CFL and in which there would be a subsidy component of Rs 3,04,000 in order for survivor to compete with this option the survivor system would have to be priced at less than Rs. 1.0 lac Alternatively one would have to lobby for same element of subsidy as in a PV lantern

5.2 *INDUSTRIAL SECTOR*

Questionnaires were designed for the industry sector and mailed to about 900 industrial houses all over the country Same questionnaires were also sent to a number of possible users of SAWEG like department of fisheries etc The response was very small but this is not surprising as there are indeed few industries where small applications can not be met by the centralized power generation system. The data received has been analyzed and is presented in tables 1 & 2 while the list of organizations which replied to our questionnaires is given in annexure The response is not very encouraging yet some of these organizations or similar organizations can be approached for the purposes of marketing

5.3 *OTHER SECTORS*

Attempts were made to assess the market potential in other sectors described below·

Army· Discussions were held with the office of Dep Director General (Utilities). E-in-C branch The officials claim that there is a very large requirement for such systems in army provided these are designed so that the equipment can be dismantled and transported This is a very important criteria technology selection with the Army

Department of Light houses and Lightships· Discussions were held with Dep Director General (Elect) according to whom the department was very keen on evaluating these options

Department of Telecommunications: The department is seriously pursuing the option of meeting there small electricity requirements from renewable based units In the current year orders have been placed for supply of 60,000 units PV of 70 watt each which amounts to 4.2 MW.

Indian Railways. The Indian Railways have installed more than 3.000 units of 12 watt CFL, 93 units of 40 watt station lighting by PV. 40 watt PV units are being used for electrification of gates and unmanned crossings. 127 units of 30 to 40 watt PV are being used signal lighting This shows that there is a potential for meeting small remote applications of railways by renewables. Small wind turbines are also appropriate for railways as these would generate higher power near rail road due to the gusts of wind created by fast moving trains.

Door Darshan Door darshan installed PV units in the range of 300 to 400 watt for powering VLF transmitters

ONGC ONGC is known to have been taking interest in small wind turbines for offshore applications Recently the organization 30-60 watt PV units for offshore lighting and for cathodic protection.

Crop	Agricultural Area (mha)	Area under irrigation (mha)	Area not irrigated (mha)	Irrigation requirement MkWh
Rice	38 81	16 973	21.837	54177
Wheat	23.06	17.890	5.170	3345
Pulses	21.27	21 353	198.447	347862
Others..				
Coarse grains	36.55			
Food grains	119.69			
Ground nut	6.84			
Rpseed & Mstrd	4 62			
Oilseed	20.13			
Sugarcane	3.28			
Cotton	6.46			
Jute & Mesta	0 96			
Total	**282.1**	**56.216**	**225.454**	**405384**

Exhibit 4: Yearly Energy Requirement for Area Under Crops Yet to be Irrigated

The Data is for 1987/88
Energy Requirement is based on average figures available for different crops per ha for different categories of farmers and different regions of country

5.4 COMPETING OPTIONS

Though there appears to be a significant potential for the use of SAWEG in India and other developing countries, the conventional competing options of conventional technologies are well established or are priced low In the rural sector in India, the competing options are diesel, kerosene, sometimes firewood, micro hydro or grid electricity All these options are priced low and can be afforded by the users. However, the cost of survivor machines is so high that it becomes unaffordable to the user. Apart from the cost, the other factors that favor the conventional technologies in the market are reliability and convenience and ease in operation It should be noted that in the process of selection of a technology or process, reliability in supply is most important criteria which sometimes overrides the criteria of cost One of the environmentally friendly and nonconventional technologies, the solar photovoltaic systems, despite being costly have been found to be acceptable in certain market segments due to several other reasons such as; availability in very small ratings (10 watt), high reliability, transportability and in some cases zero maintenance We feel that it would be extremely difficult to market survivor systems due to above reasons and due to the fact that there are other SAWEG in the market available at much lower costs

6.0 CONCLUSIONS & RECOMMENDATIONS

6.1 CONCLUSIONS

The study, though encouraging in the sense that it indicates a high potential for the use of SAWEG like systems in developing nations and India, does not paint a very bright picture about the prospects of actually marketing the machines in the existing conditions. The study has shown that the technology has relevance and large potential for use in all the market segments considered However, the cost of competing options (not only of the conventional technologies but also of the other SAWEG) is so low that it becomes outright impractical to sell the survivor systems Even if the Survivor costs are made competitive with the costs of existing SAWEG in the market, the actual marketing potential would still be too low and with too many uncertainties to justify any kind of venture in large scale manufacturing of the systems in India While it is expected that large scale manufacture will be bring down the costs to some extent, the technology would still be far from competitive.

The only way this technology can become commercially attractive to the user is through a certain incentives and some policy decisions on the means and ways of rural electrification The governments policy towards the development and promotion of SAWEG is yet to crystalize Unless there is comprehensive package of incentives to the users as in the case of grid connected wind turbines, the market will continue to remain immature. Although there has been much interest in wind electric generators from both private sector and govt organizations, the technology being vigorously pursued is grid connected wind turbines which are suitable only for regions with stable grid One of the potential technologies for decentralized electricity generation, the SAWEG from few hundred watts to 10 kW, have not been considered or pursued in the wind energy programs of the country

6.2 RECOMMENDATIONS

We suggest following strategy towards business development

- To postpone the planned manufacturing facility for SAWEG till the market is mature

- To set up an assembly plant to assemble the whole turbine from off the shelf and imported components. However this assembly plant should not be in the nature of mass series production, but on a much smaller scale with the capacity to assemble 2 to 3 turbines in a week

- To market the systems. REPL has to reduce the price in order to introduce the systems at a price lower than the price of other similar systems in India.

- Schemes should be worked out with the help of financial institutions to hire out systems to the users or to offer the systems to users on easy installments

- REPL should build and operate systems for remote communities for a certain reliability (i e. to meet a certain minimum firm power of a high priority load) at a certain agreed rate of electricity to the users

- REPL should set up some demonstration units.

- Lobbying for a clear set of incentives from government should simultaneously be carried out by means of representations, seminars, guest lectures and articles in Newspapers.

- A sustained advertizing campaign should be carried out to increase the awareness of all concerned towards these systems Emphasis should be laid on environment friendly nature of technology and the teetering system of the turbine.

- REPL should also lobby with international aid agencies for soft loans or grant under the framework of environment and sustainability

- Initially this activity does not require a major manpower commitment In fact one qualified marketing cum engineer professional for marketing and vendor development and two to three trained technicians for assembly and service would suffice. The manpower can be increased gradually with the increase and expansion of activities

- The target segment for initial marketing should be government and public sector organizations, hotels, plantations, diaries, cooperatives, state nodal agencies The target geographical regions should be entire coastal stretch of India with emphasis on Gujarat, Tamilnadu and Kerala Attempts can also be made to sell the systems for off shore applications

Annexure I: Questionnaire Response

Table 1 Application wise analysis of questionnaire response

Industry particulars	Drying purposes		Battery charging purposes		Communication purposes		Microwave repeaters purposes		Lighting purposes		Grinding purposes		Compressed air for tooling/ other purposes		Air-conditioning purposes		Space heating purposes		Fluid pumping purposes		Water-ammonia refrigeration system purposes	
	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating
National Research Centre for Spices, Calicut	18	1 5 kW	18	1 5 kW	18	1 5 kW	18	1 5 kW	40	4 kW	40	1 5 kW	10	1 5 kW	18	4 kW	10	1 kW	18	1 kW	10	1 kW
Cadbury India Ltd , Dist Pune	-	-	-	-	-	-	-	-	10	1 kW	-	-	-	-	-	-	-	-	10	30 kW	-	-
Directorate of Oilseeds Research, Hyderabad	-	-	10	1 kW	-	-	-	-	-	1kW	-	-	10	4 kW	18	4 kW	10	1 5 kW	-	-	-	-
	-	-	-	-	-	-	-	-	10	20 kW	-	-	-	-	-	-	-	-	-	-	-	-
Kudremukh Iron Ore Co Ltd , Chikkamangalur	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Western India Plywoods, Balliaputnum, Kerala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	8 kW	-	-
Panchura Estates Ltd , Nilgiris, Tamil Nadu	10	20 kW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rossell Industries Ltd , Panitola, Assam	40	1 5 kW	10	1 kW	-	-	-	-	150	1 kW	-	-	10	1 5 kW	10	8 kW	-	-	18	1 kW	-	-

Industry particulars	Drying purposes		Battery charging purposes		Communication purposes		Microwave repeaters purposes		Lighting purposes		Grinding purposes		Compressed air for tooling/ other purposes		Air-conditioning purposes		Space heating purposes		Fluid pumping purposes		Water-ammonia refrigeration system purposes	
	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating
NOCIL Thane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J K Paper Mills Dist Rayagada, Orissa	-	-	-	-	-	-	-	-	750	15 kW	-	-	-	-	-	-	-	-	150	20 kW	-	-
Cheviot Co Ltd , Calcutta	-	-	-	-	-	-	-	-	18	20 kW	-	-	-	-	10	-	-	-	-	-	-	-
Pond's India Ltd , Kodaikanal	-	-	10	1 5 kW	-	-	-	-	150	8 kW	01	4 kW	3	30 kW	-	-	10	1 kW	10	1 kW	-	-
Madhya Bharat Papers Ltd Bilespur, M P	-	-	-	-	-	-	-	-	10	150 kW	-	-	-	-	-	-	-	-	-	-	-	-
Bholuka Aluminium Ltd , Mysore	-	-	10	1 kW	-	-	-	-	350	20 kW	-	-	10	20 kW	-	-	-	-	10	1 5 kW	-	-
Roopachirra Tea Estate, Hailakamdi, Assam	-	-	-	-	-	-	-	-	10	4 kW	-	-	-	-	-	-	-	-	-	-	-	-
Adarsh Chemicals and Fertilizers Ltd , Surat	-	-	10	1 kW	10	1 kW	-	-	150	15 kW	10	1 5 kW	10	15 kW	-	-	-	-	-	-	-	-
Man-made Textile Research Association, Surat	-	-	10	1 kW	-	-	-	-	10	4 kW	10	1 kW	10	1 5 kW	10	8 kW	-	-	10	4 kW	-	-

Industry particulars	Drying purposes		Battery charging purposes		Communication purposes		Microwave repeaters purposes		Lighting purposes		Grinding purposes		Compressed air for tooling/ other purposes		Air-conditioning purposes		Space heating purposes		Fluid pumping purposes		Water-ammonia refrigeration system purposes	
	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating	No	Rating
National Dairy Research Institute, Karnal	18	15 kW	10	4 kW	-	-	-	-	150	1 kW	10	1 5 kW	10	4 kW	75	8 kW	-	-	10	15 kW	-	-
ITC-Bhadrachalam Paper Boards Ltd , Secunderabad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Someswara Cements Ltd , Adilabad, A P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nath Pulp and Paper Mills Ltd , Aurangabad	-	-	10	1 kW	-	-	-	-	10	3 kW	10	1 kW	10	20 kW	10	4 kW	-	-	10	20 kW	-	-
TATA Pharma Raigad, Orissa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	4 kW	-	-
Central Institute and Fisheries Technology, Cochin	-	-	-	-	-	-	-	-	350	15 kW	10	1 5 kW	10	1 5 kW	18	4 kW	-	-	10	4 kW	10	8 kW
Bombay Extractions Ltd , Bombay	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-
Jayshree Tea Industries, Calcutta	40	22 kW	-	-	-	-	-	-	750	1 5 kW	150	15 kW	-	-	-	-	-	-	18	4 kW	-	-

Table 2: Criteria on selection of technology

Application	Industry Particulars	Criteria which are not important for power supply selection
(a) Crop drying	National Research Centre for Spices, Calicut	1 Unmanned power supply
		2. Remote control
		3. Quiet and unnoticed operation
		4 Modular capacity addition
	Panchura Estate Ltd, Nilgiris	1 Unmanned power supply
		2 Remote control
		3 Quiet and unnoticed operation
	Rossel Industries Ltd, Assam	1 Capital cost
		2. Remote control
	National Dairy Engg Division, Karnal	1 Capital cost
		2 Unmanned power supply
		3 Dismantelling the unit
		4 Remote control
	Jayashree Tea Industries, Calcutta	1 Remote control
		2. Quiet and unnoticed operation
(b) Battery charging	Nath Paper & Pulp Mills Ltd, Aurangabad	1 Unmanned power supply
		2 Weather resistant
		3 Remote control
		4 Modular capacity addition
	National Diary Research Institute, Karnal	1. Capital cost
		2 Availability of instant power as and when the need arises

Application	Industry Particulars	Criteria which are not important for power supply selection
		3. Remote control
	Man-made Textile Research Institute	1. System and service life
		2. Remote control
		3 Weather resistant
	Bholuka Aluminium Ltd , Mysore	1. Quiet and unnoticed operation
		2. Remote control
		3 Unmanned power supply
	NOCIL, Thane	1 Remote control
	Rossell Industries Ltd , Assam	1 Capital cost
	Directorate of Oilseed Research, Hyderabad	1 Remote control
	National Research Centre for Spices, Calicut	1 Remote control
		2 Unmanned unattended power supply
		3 Quite and unnoticed operation
		4 Modular capacity addition
(c) Communication purposes	National Research Centre for Spices, Calicut	1 Unmanned power supply
		2 Remote control
		3 Quiet and unnoticed operation
		4 Modular capacity addition
	NOCIL, Thane	1 Remote control
	Nath's Paper & Pulp Mills Ltd , Aurangabad	1 Unmanned power supply
		2 Weather resistant
		3 Remote control

Application	Industry Particulars	Criteria which are not important for power supply selection
		4. Modular capacity addition
(d) Lighting purposes	National Research Centre for Spices, Calicut	1. Unmanned power supply
		2. Remote control
	Cadbury Industries Ltd , Pune	1. Ease in mobility and dismentelling the unit
		2 Quiet and unnoticed operation
	Directorate of Oilseeds Research, Hyderabad	1 Remote control
	-	1 Modular capacity addition
		2 Remote control
	Assam	1. Capital cost
	NOCIL, Thane	1 Remote control
	Madhya Bharat Papers Ltd , Bilaspur	1 Maintenance and service backup
	Bholuka Aluminium Ltd , Mysore	1 Unmanned power supply
		2 Quiet and unnoticed operation
	Roopa Cherra Tea Estate, Assam	1 Availability of instant power as and whther need arises
		2 Maintenance and service backup
		3 Ease in mobility and dismentelling the unit
		4 Modular capacity addition
	Man-made Textile Research Association, Surat	1 Unmanned power supply
		2. Weather resistent
		3 Remote control

Application	Industry Particulars	Criteria which are not important for power supply selection
		4 Modular capacity addition
	N.D.R.I., Karnal	1. Availability of instant power
		2 Unmanned power supply
		3. Ease in mobility and dismantelling the unit
		4. Remote control
	Nath Paper and Pulp Mills, Ltd., Aurangabad	1 Availability of instant power as and when the need arises
		2 Quiet and unnoticed operation
		3 Modular capacity addition
	Central Institute of Fisheries Technology, Cochin	1 Capital cost
		2 Ease in mobility and dismantling the unit
		3. Remote control
		4 Modular capacity addition
	Jayshree Tea and Industries, Calcutta	1. Ease in mobility and dismantling the unit
		2 Weather resistant
		3 Modular capacity addition
(e) Grinding purposes	Jayshree Tea and Industries, Calcutta	1 Unattended power supply
		2. Ease in mobility and dismantling the unit
		3 Weather resistant
		4 Remote control
		5 Quiet and unnoticed operation
		6 Modular capacity addition

Application	Industry Particulars	Criteria which are not important for power supply selection
	Central Institute of Fishing Technology, Cochin	1 Capital cost
		2. Ease in mobility and dismantling the unit
		3 Modular capacity addition
		4 Remote control
	Nath Paper and Pulp Mills Ltd., Aurangabad	1 Availability of instant power as and when the need arise
		2 Quiet and unnoticed operation
		3 Modular capacity addition
	N D R I., Karnal	1 Availability of instant power as and when need arises
		2 Unattended power supply
		3 Ease in mobility and dismantling the unit
		4 Remote control
	National Research Centre for Spices, Calicut	1 Remote control
		2 Unattended power supply
(f) Compressed air for tooling or other purposes	NOCIL, Thane	1 Remote Control
	Directorate of Oilseeds Research, Hyderabad	1 Remote control
	Rossel Industries Ltd., Assam	1. Capital cost
	Bholuka Aluminium Ltd., Mysore	1 Remote control
		2. Quiet and unnoticed operation
		3 Weather resistant

Application	Industry Particulars	Criteria which are not important for power supply selection
		4 Unattended power supply
	Man-made Textile Research Institute, Surat	1 Ease in mobility and dismantling the unit
		2 Weather resistant
		3 Remote control
		4 Quiet and unnoticed operation
	N.D R.I., Karnal	1 Unattended power supply
		2 Ease in mobility and dismantling the unit
		3 Remote control
		4 Quiet and unnoticed operation
	Nath Paper and Pulp Mills Ltd., Aurangabad	1 Availability of instant power as and when need arises
		2 Quiet and unnoticed operation
		3 Remote control
	Central Institute of Fisheries Technology, Cochin	1 Capital cost
		2 Ease in mobility and dismantling the unit
		3 remote control
		4 Modular capacity addition
(g) Air-conditioning purposes	Central Institute of Fisheries Technology, Cochin	1 Modular capacity addition
		2 Remote control
		3 Ease in mobility and dismantling the unit
	Tata Pharma, Raigad	1 Ease in mobility and dismantling the unit

Application	Industry Particulars	Criteria which are not important for power supply selection
		2 Weather resistant
		3. Remote control
		4 Quiet and unnoticed operation
	Nath Pulp and Paper Mills Ltd., Aurangabad	1 Availability of instant power as and when the need arises
		2 Quite and unnoticed operation
	N D R.I , Karnal	1 Unattended power supply
		2 Ease in mobility and dismantling the unit
	Man-made Textile Research Association, Surat	1 Unattended power supply
		2. Weather resistant
		3. Remote control
		4 Quite and unnoticed operation
	Rossel Industries Ltd , Assam	1 Capital cost
	Directorate of Oilseeds Research, Hyderabad	1 Remote control
	NOCIL, Thane	1 Remote control
	National Research Centre for Spices, Calicut	1 Unattended power supply
		2 Remote control
Water/fluid pumping	National Research Centre for Spices, Calicut	1 Unattended power supply
		2. Remote control
	NOCIL, Thane	1 Remote control
	Cadbury India Ltd., Pune	1 Modular capacity addition
		2 Quiet and unnoticed operation

Application	Industry Particulars	Criteria which are not important for power supply selection
		3. Remote control
		4 Weather resistant
		5. Ease in mobility and dismantling the unit
		6. Unattended power supply
	Western India Plywoods, Kerala	1 Remote control
	Rossel Industries Ltd	1 Capital cost
	Bholika Aluminium Ltd	1 Capital cost
		2 Unattended power supply
		3 Remote control
		4 Quiet and unnoticed operation
		5 Modular capacity addition
	Man-made Textile Research Association, Surat	1 Unattended power supply
		2 Weather resistant
		3 Remote control
		4 Quiet and unnoticed operation
	N.D.R I , Karnal	1 Remote control
		2 Ease in mobility and dismantling the unit
		3 Unattended power supply
	Nath Paper and Pulp Mills Ltd., Aurangabad	1 Quiet and unnoticed operation
	Tata Pharma, Raigad	1 Modular capacity addition
		2 quiet and unnoticed operation
		3 Remote control

Application	Industry Particulars	Criteria which are not important for power supply selection
		4. Ease in mobility and dismantling the unit
	Central Institute of Fisheries Technology, Cochin	1. Capital cost
		2. Ease in mobility and dismantling the unit
		3 Remote control

Annexure II: Future Concepts

Firstly, we describe the systems which are either being demonstrated or await further technological breakthroughs before being extensively used.

Variable and fixed geometry Darrieus rotors: Developed at the University of Reading in U K. This model is result of an effort to limit the speed of rotation of a Darrieus rotor

Savonious rotor This is a vertical axis turbine with two half cylinders as blades Though not as efficient as the horizontal axis wind turbines with aerofoil blades, these systems have been found to be useful due to the ease with which the rotor can be fabricated. This rotor named after its inventor Sigurd Savonious was patented in 1929. Being very simple in construction, it has the potential for large scale use in decentralized mode particularly in developing countries. Experimentation is being carried out with improved versions of Savonious rotor

Wind-diesel hybrid systems: These systems are meant for decentralized applications where the diesel consumption can be significantly reduced Many systems have been installed on an experimental basis to work out the optimum configurations and control strategies (discussed above).

Offshore turbines There are several benefits associated with offshore installations, most important being that the wind speeds are undisturbed by surface roughness and terrain. The first offshore windfarm was installed 2 5 km off the shore in Denmark The foundation design, erection and costs are the major constraints in such projects Shores offer additional resource areas and with the rise in fuel prices etc. and further technological developments in wind turbines it is expected that more offshore windfarms will come up In the context of SAWEG and autonomous systems offshore concept can be persued for energization of warning signals, guiding lights and other applications like offshore drills etc

Some turbines have been experimented at laboratory level while for others only concepts have been formulated A brief description of each of these possible systems is given below

Circular Track Wind Turbine The concept was initially developed in 1930 in U S A but somehow it was never tried In this concept vertical aerofoil sections move on circular tracks and generators are installed at fixed points along the track driven by a structure The concept is useful in generating electricity both on large and small scales

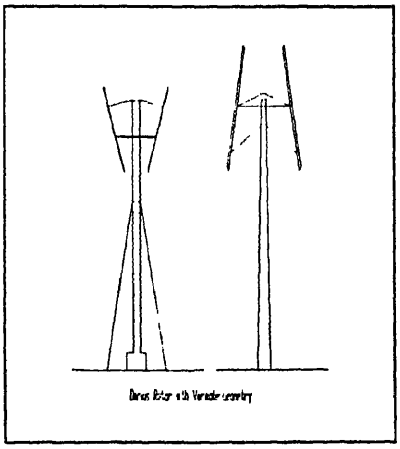

Figure 2 Darrieus Rotors With Variable Geometry

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